Potential of Tabas Stone Waste as Additional Material of Concrete for Coastal Protection Structures

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Abstract

The coast has natural protection, but if this natural protection is damaged, the coast can be protected with coastal structures. Concrete is one of the main materials for coastal protection structures such as breakwaters, jetties, groins and revetments. Concrete used in coastal environments must have high strength performance to face the challenges of corrosive seawater, high humidity, and extreme temperature changes. Tabas stone is a Basaltic Scoria stone resulting from the eruption of Mount Agung which is used by the people of Bali as an ornament in Balinese buildings. Tabas stone pieces that do not match the size are discarded and become waste. In this study, tabas stone waste was used as an additional material for fine aggregate of 0%, 10%, 20% with a concrete design compressive strength of 42 MPa. Cylindrical samples were produced then soaked in the sea and at the river mouth. Furthermore, the samples were tested to be compared with concrete samples with curing in standard water conditions at the age of 28 days. The test results showed that the effect of seawater and brackish water immersion caused a significant decrease in the compressive strength of the concrete. The addition of the percentage of tabas stone also caused a decrease in the compressive strength of the concrete. Thus, tabas stone have small potential to be used as an additional material for concrete filler for coastal building construction.

Keywords

Coastal Protection, Concrete, Tabas Stone Waste, Compressive Strength

Introduction

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water with or without additives that form a solid mass (SNI-03-2834-2000). Concrete is widely used for infrastructure development both on land and at sea. Coastal areas are the regions where land and sea meet. In coastal areas, the beach is protected by sand, coral and mangroves as natural protection. However, if this natural protection is damaged, concrete can be used as a coastal protection structure.

Based on the geological map of Bali, tabas stone is the result of the eruption of Mount Agung which is located in the eastern area (Wibawa and Maharani, 2023). The results of petrographic observations show that the physical condition of the tabas stone incision under a microscope includes basaltic scoria stone, namely material in the form of a volcanic eruption with a basic composition. Wibawa and Maharani (2023) stated that the existence of tabas stone is

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currently spread across Kubu District and Bebandem District in Karangasem Regency, eastern part of Bali Island. Tabas stone is used by the Balinese people as an ornament in Balinese buildings. The results of cutting tabas stone that do not match the size will then be discarded and become waste.

The use of tabas stone waste as a substitute for fine aggregate in concrete mixtures has been studied by Salain et al. (2017). Tabas stone waste is processed into granular or powder form. Approximately 30% of the amount of tabas stone processed by craftsmen ends up as waste and has not been utilized properly. The results of their study indicate that the use of a mixture of natural fine aggregate and tabas stone waste can produce better strength than fine aggregate using only tabas stone waste. Intara et al. (2013) have used the use of tabas stone powder as a partial substitute for Portland cement using cylindrical concrete test objects. The test results showed that tabas stone powder showed good pozzolanic reactivity in terms of compressive strength, modulus of elasticity, splitting tensile strength and permeability so that it is worthy of being considered as a component of composite Portland cement. The optimal use of tabas stone powder as a partial substitute for cement in concrete applications ranges from 5-10% so that it is able to show performance that is equivalent to and/or exceeds the performance of concrete with 100% Portland cement adhesive.

Another research on utilizing tabas stone waste was conducted by Astariani et al. (2023). Tabas waste as a partial substitution of coarse aggregate in concrete mixtures with the addition of polyester resin coating to minimize the pores on the aggregate. Test results showed that the coating of tabas stone using polyester resin was able to reduce the level of water absorption and the optimum compressive strength of coarse aggregate substitution using tabas was obtained at variations of 50% crushed stone 50% tabas stone. Salain et al. (2023) also studied the use of tabas stone waste as coarse aggregate to discover the effect on varied proportion of cement, fine aggregate and coarse aggregate in concrete. The unit weight and the elastic modulus of concrete decrease with increasing water cement ratio at fixed proportions of cement and aggregates and increase with increasing proportion of aggregates at fixed water cement ratio.

By utilizing tabas stone waste in making concrete, it is expected to reduce environmental pollution, and can be used to improve the performance and durability of concrete materials in the environment, especially in the sea. Several research for the effect of concrete compressive strength in seawater environment have been done, with the results of compressive strength of concrete with freshwater curing treatment is greater than the seawater curing treatment (Nurtanto et al., 2018; Wedhanto, 2017; Wora and Segu, 2014; Zahlim et al., 2022). However, in the marine environment, research on concrete that utilizes tabas stone waste as a substitute or additional material for fine aggregate is still not widely carried out, so in this study an analysis of the potential use of tabas stone waste in making concrete for coastal protection buildings will be carried out.

Methodology

The method used in this study is an experimental method conducted at the Structure and Materials Laboratory, Civil Engineering Study Program, Faculty of Engineering, Udayana University. The research steps include preparation of tools and materials, characterization of fine and coarse aggregates, sample making, and immersion using seawater and fresh water. Furthermore, compressive strength testing was carried out on the samples, data calculation and recapitulation, and analysis of the results. The data were analysed using a descriptive analysis approach to evaluate the effect of the type of soaking water on the compressive strength of concrete containing tabas stone waste as an additional fine aggregate.

This study uses the variable percentage of tabas stone waste as an additional material for fine aggregate with proportions of 0%, 10%, and 20%. The treatment variables involve the type of soaking water, namely sea water, brackish water, and standard water in laboratory with a test age of 28 days. The test sample is cylindrical with a size of 150 mm x 300 mm, and the total number of test objects is 27 pieces.

The seawater and brackish water used in this study were located at Seseh Beach, Munggu, Bali as shown in Figure 1 and Figure 2. The results of water quality tests are summarised in Table 1. The results showed that that brackish water and salt water at the test location had different value on several parameters such as pH value, Total Dissolve Solid (TDS), electrical conductivity and salinity.

Figure 1. Seawater Immersion

Figure 2. Brackish Water Immersion

Table 1. Result of Water Quality Test

Type of Water	pH	Total Dissolve Solid/TDS (mg/L)	Electrical Conductivity (µmhos/cm)	Salinity (‰)
Brackish Water	7.76	460	912	0.4
Salt Water	7.76	20,600	42,600	25.5

The manufacture of test specimens involves the process of mixing fresh concrete which is carried out based on calculations from the Mix Design planning. In this process, all materials are mixed together with the addition of admixtures. Sample of Tabas Stone Powder used in the concrete mixing is shown in Figure 3.


Figure 3. Tabas Stone Powder

After the concrete mixture becomes homogeneous, the mixture is poured into a cylindrical mould. The test specimens are released from the mould after 24 hours. Then, the test specimens are cured in seawater, brackish water, and standard water conditions for a period of 28 days. After this period, the test specimens are taken back to the laboratory for compressive strength testing as shown in Figure 4.


Figure 4. Compressive Strength Test

Concrete mix planning aims to determine the right proportions between cement, fine aggregate, coarse aggregate, and water in the concrete mixture. The results of the concrete mix planning for each cubic meter can be seen in Table 2.

Table 2. Concrete Mix Proportion for each m^3

Mix by Weight	**Water (kg)**	**Cement (kg)**	**Fine Ag. (kg)**	**Coarse Ag. (kg)**	**Coarse Ag. 1/2 (kg)**	**Coarse Ag. 2/3 (kg)**
Each m^3 concrete	173	569	654	814	329	485
Weight Ratio Cement : Fine Ag : Coarse Ag		1	1.15	1.43	0.58	0.85

Results and Discussion

The results of the study on concrete testing using a strength tester or compressive strength machine showed the effect of immersion at the age of 28 days, as well as the addition of 0%, 10%, and 20% of Tabas stone. The results are shown in Figure 5 and Figure 6.

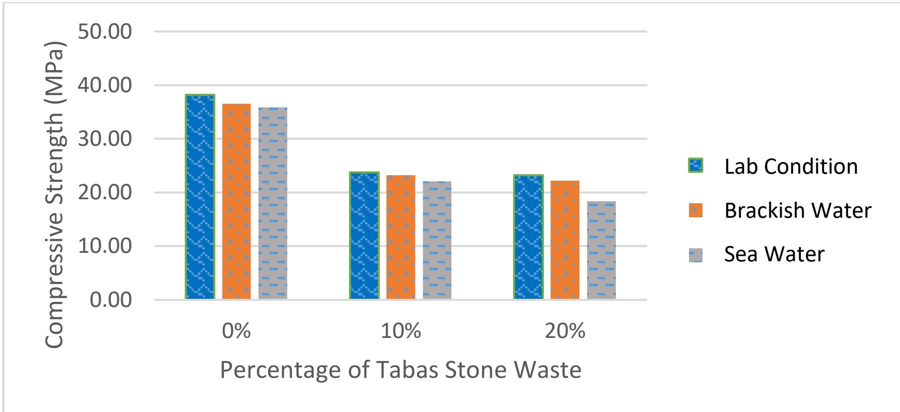

Figure 5. Comparison Results of Soaking Types for Each Percentage of Tabas Stone Waste

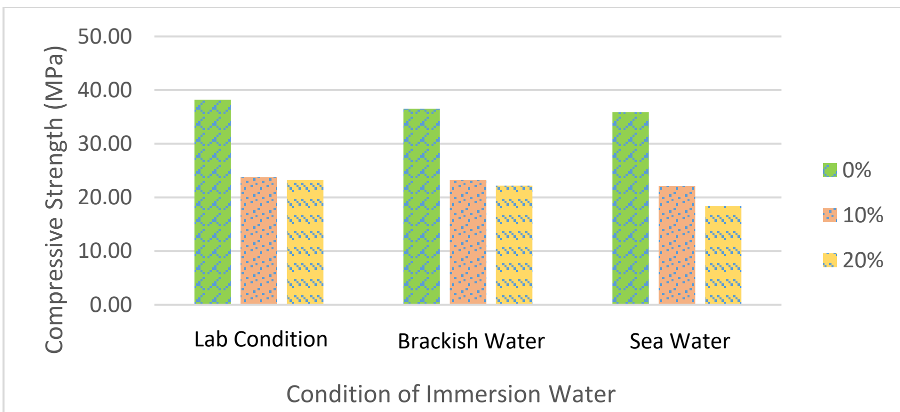

Figure 6. Comparison Results of Percentage of Tabas Stone Waste for Each Type of Soaking

Based on Figure 5 and Figure 6, it shows the results that the effect of water immersion in the river mouth and in the sea causes a significant decrease in the compressive strength of concrete from concrete with laboratory treatment conditions. From the addition of variations of Tabas stone of 0%, 10%, 20%, there is a decrease due to the addition of the stone of 37.78%, 39.28% for concrete in the laboratory condition and a decrease of 36.45%, 39.24% for concrete soaked in brackish water and a decrease of 38.42%, 48.66% for concrete soaked in sea water. From the results, generally there is an effect of water immersion in the river mouth and in the sea. Several parameters from the water quality test such as TDS, electrical conductivity and salinity could have effect on the decreasing of concrete compressive strength.

Conclusion

The results of the study showed that the effect of immersion in seawater caused a significant decrease in the compressive strength of concrete, while the compressive strength of concrete soaked in brackish water showed a greater compressive strength compared to immersion in seawater. By analysis from the addition of variations of Tabas stone by 0%, 10%, 20% caused a decrease in the compressive strength of concrete in each treatment. Therefore, Tabas stone waste have small potential to be used as a concrete filler for coastal protection buildings.

References

Astariani, N. K., Eka Partama, I. G. N., & Dwi, I. G. A. R. C. S. (2023). Influence Substitution of Tabas Stone Waste which Coated Polyester Resin to Concrete Compressive Strength. *ASTONJADRO*, *12*(3), 738–745. https://doi.org/10.32832/astonjadro.v12i3.9065

Intara, I W., Salain, I M A K., Wiryasa, N M A. (2013). Use of Tabas Stone Powder as a Partial Substitute for Cement in Making Concrete. *Jurnal Spektran*, Vol 1(1). https://doi.org/10.24843/SPEKTRAN.2013.v01.i01.p01.

National Standardization Agency. 2000. SNI 03-2834-2000. *Procedures for Making a Normal Concrete Mix Plan*.

Nurtanto, D., Rahayu, A. A., & Wahyuningtyas, W. T. (2018). Effect of Seawater and Freshwater Curing on Concrete Compressive Strength. *Scientific Journal of Civil Engineering*, 130–139.

Salain, I. M. A. K., (2017). Use of Tabas Stone Waste as Fine Aggregate in Concrete Mixture, *Seminar Nasional Sains Dan Teknologi (Senastek)* IV, pp. 1-6.

Salain, I. M. A. K., Ciawi, Y. and Sutapa, A (2023). Unit Weight and Elastic Modulus of Concrete utilizing Volcanic Stone Waste as Coarse Aggregate. *European Journal of Engineering and Technology Research*. 8, 4 (Aug. 2023), 26–29. DOI: https://doi.org/10.24018/ejeng.2023.8.4.3052

Wedhanto, S. (2017). The effect of sea water on the compressive strength of concrete made from various brands of cement in Malang City. 22(2), 21–30.

Wibawa, I M S., & Maharani, S E. (2023). Mount Agung Lava Rock Waste as Concrete Mixture Material in Environmental Sustainability Efforts. *Jurnal Ecocentrism*, *3*(1), 8–17. https://doi.org/10.36733/jeco.v3i1.5929

Wora, M., & Segu, Y. (2014). The Effect of Concrete Soaking Time in Seawater Can Decrease Concrete Quality. *Teknosiar*, 8(2), 23–34.

Zahlim, A., Bachtiar, E., & Makbul, R. (2022). Effect of Seawater Curing on the Compressive Strength of High-Quality Concrete Using Fly Ash as a Sand Substitute. *Borneo Engineering*: *Journal of Civil Engineering*, 1(1), 1–10.